Real-Time Indoor Proximity & Geo-Fence Based Digital Signage Advertising

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***Abstract*– Advertising has entered in to an interactive communication mode due to the widespread application of the internet. In the dawn of mobile communication systems and smart phone devices, consumers' preferences can be pre-identified. Advertising messages can therefore be delivered to consumers at the right time and at the right place with the right message. By taking into consideration of this new advertising possibility, designing personalized advertising to meet consumers' needs becomes an important issue. This research conveys a personalized two-way communication method using proximity marketing, navigation and geo-fencing technologies to enhance the connection between modern technologies with marketing for the development of the marketing industry.**

Keywords–personalized, two-way, proximity, navigation, geo-fence

I. INTRODUCTION

Product, Price, Promotion and Place (4 P's) is the best-known way to define the "Marketing Mix". The marketing mix refers to the set of actions, or tactics, that a company uses to promote its brand or product in the market [1]. Advertising is only one element in that promotion mix, but it often considered prominent in the overall marketing mix design [2]. It is an audio or visual form of marketing communication that employs an openly sponsored, non-personal message to promote or sell a product, service or idea [3]. This element is one of the most considerable element in every industry, to achieve their overall market objectives.

Various types of methods, such as newspapers, magazines, television, websites, digital signage etc. are used to perform adverting. All these advertising techniques have many common characteristics, among those mainly two characteristics have become common problems in adverting recently [4], which are mentioned as follow:

- One-way communication: Message move from advertiser to customer but cannot receive a real feedback to the advertiser from customers.
- Non-personal: Advertised message is not directed to an individual.

These above-mentioned problems have serious impact for advertisers as well as the customers, so it leads to an inefficient, bothering advertising process which is unable to fulfill customer expectations and failure in achieving the advertising objectives from the advertiser's perspective.

This research paper introduces an effective indoor and outdoor advertising process that has the main objective to overcome the above stated problems and fulfill customer satisfaction as well as the advertiser's expectations. In the proposed solution, Indoor advertising process happens using a mobile application and beacon technology and Outdoor advertising process happens via digital signage advertising method by displaying personalized adverting based on identified customer group preferences near to digital signage. This entire solution performs adverting process in a personalized way with procuring advertiser to receive a real feedback from customers.

II. LITERATURE SURVEY

Throughout the years many researchers and many real-world applications have come up to the world to improve the traditional advertising process. Most are based on IoT, Proximity marketing and Digital Signage.

Carrefour, Walmart, Eat, Meadowhall [5], [6] are some main examples in the world that have innovated their business process through beacon and IoT concept. Carrefour uses wide-ranging iBeacon network in all 28 its hypermarkets for orientation inside market. EAT food-to-go chain use Weve's beacon technology which let the company to access details about customer food preference and make decisions and depicts how costumer's behavior can be influenced by using a loyalty application to store retailer's loyalty cards and push out notifications to mobile users. Meadowhall Shopping Centre in Sheffield uses iBeacon technology to Ladies Night

event and allows customers to enjoy brands offers, discounts. Mobile users had to install a loyalty app to receive real time offers notification in their mobile phones depend on the location when they are inside the beacon range via BLE beacon technology.

Even though these solutions contain some drawbacks and there are some other aspects that did not addressed to improve the advertising process more innovatively.

Below table 1 depicts the uniqueness of the proposed advertising solution which is known as "PRESTO" when compared to available advertising solutions with the use of beacon and IoT.

TABLE 1: PRESTO comparison with existing applications

Applications/ Features	Carrefour	Eat	Meadowhall	Walmart	PRESTO
Use Beacon technology	✓	✓	✓	✓	✓
Personalization	×	×	×	×	✓
Two-way communication	×	×	×	×	✓
Indoor Navigation	✓	×	×	×	✓
Outdoor advertising	×	×	×	×	✓

III. METHODOLOGY

This research focuses on achieving personalized, two way indoor and outdoor advertising process with the interaction of the following four main modules.

- Proximity sensor subsystem and multilingual information delivery module
- Customer preference based shopping guide module
- Geo fence based digital signage module
- Data management and statistical analysis module

Figure 1 depicts block diagram of the entire system overview which combines above mention four main modules.

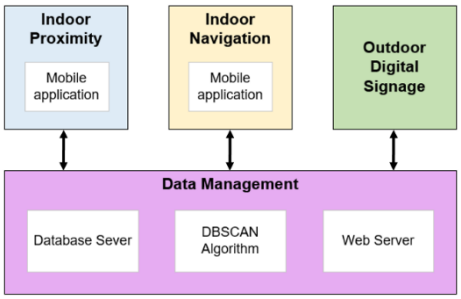

Fig. 1. Block diagram of the system

Proximity sensor module and shopping guide module focus on personalized, two-way indoor advertising process, digital signage module focuses on personalized, two-way outdoor advertising process. These three modules perform specific functionalities with the interaction of data management module. Figure 2 depicts the high-level architecture of the proposed solution.

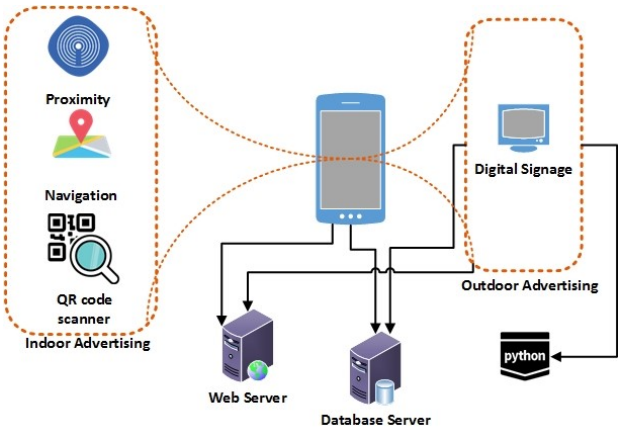

Fig. 2. High-level architecture

Data management module gathers and stores customer details who are registered with the mobile application, customer preferences collected through social media, questionnaire, advertising feedback. These data are analyzed and perform decision-making process to obtain personalized messaging in outdoor advertising. Decision-making process is performed using DBSCAN clustering algorithm which is deployed as a web service. DBSCAN is a data clustering algorithm. Algorithm generates cluster based on sixteen different customer preferences. Algorithm requires two parameters which are,

- Ɛ epsilon - The maximum distance between two samples for them to be considered as in the same neighborhood
- MinPts - The number of samples (or total weight) in a neighborhood for a point to be considered as a core point. This includes the point itself.

Figure 3 flow chart clearly indicates the decision-making process with the use of DBSCAN algorithm.

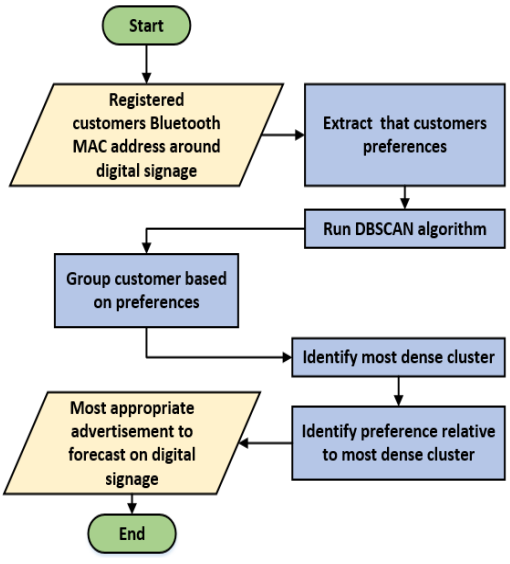

Fig. 3. Flow chart of the DBSCAN algorithm

Data management module compromise of four sub components. Those components are as follow:

- Database server-Maintain all databases which contain customer and advertising data
- Decision making component- Execute DBSCAN algorithm
- Statistical analysis component- Generate different charts, reports using Power BI tool to analyses different behaviors in advertising and customer shopping behaviors
- Value-added services administration component- Facilitates to upload advertisement that required to forecast in indoor and outdoor through a web application to the web server.

A. Personalized, two-way indoor advertising process

Proximity module and shopping guide module together facilitate the personalized, two-way indoor advertising process.

- *Proximity sensor subsystem and multilingual information delivery module*

Proximity module enables the end-users to view indoor location based value added services through a mobile application that can detect advertising signals sent by tiny devices such as beacons, to view location based value-added services. IBeacon protocol is used to communicate between the mobile application and the beacon. Notifications are automatically pushed to the mobile phone when the mobile application installed smart device come to a certain location. Users need to have Bluetooth Low Energy (4.0) enabled devices with the dedicated mobile application installed on them to receive and enjoy the messages beacons send when user is in proximity. Figure 4 indicates the distance analyzing process through the mobile application.

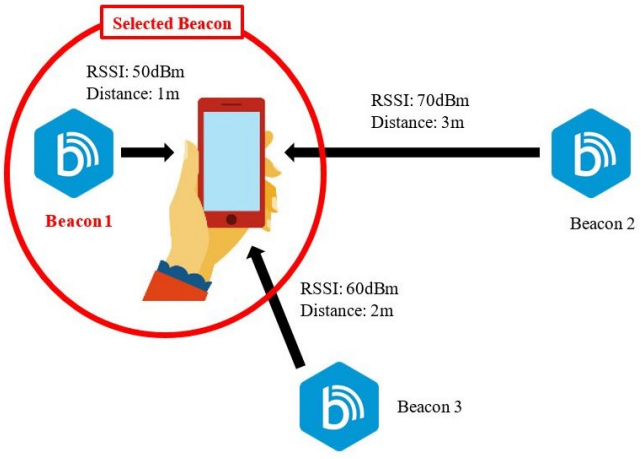

Fig. 4. Beacon Management through the Mobile Application

By analyzing the broadcasted packet data and the RSSI, Tx power values, the distance from the mobile device to the beacon is calculated and the nearest beacon is identified. This identified beacons UUID and the mobile device user's username is forwarded to the web service. By analyzing collected user data an appropriate personalized advertisement from the web service and display it in the user's mobile device. Following figure 5 depicts the Content retrieving process from the received signal.

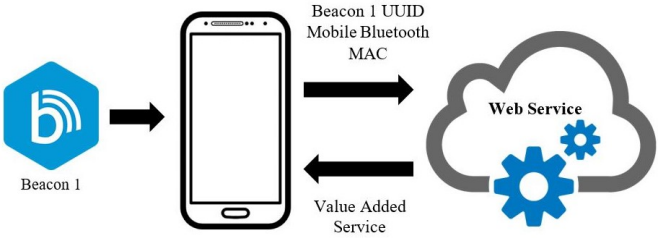

Fig. 5. Content retrieving process from the received signal

As a result, two users in the same location getting the signal from the same beacon will not get the same advertisement. The advertisement will be influences with user's preferences. The mobile application needs Wi-Fi to connect to the web service which is deployed in cloud. That process algorithm is defined in the following figure 6 flow chart.

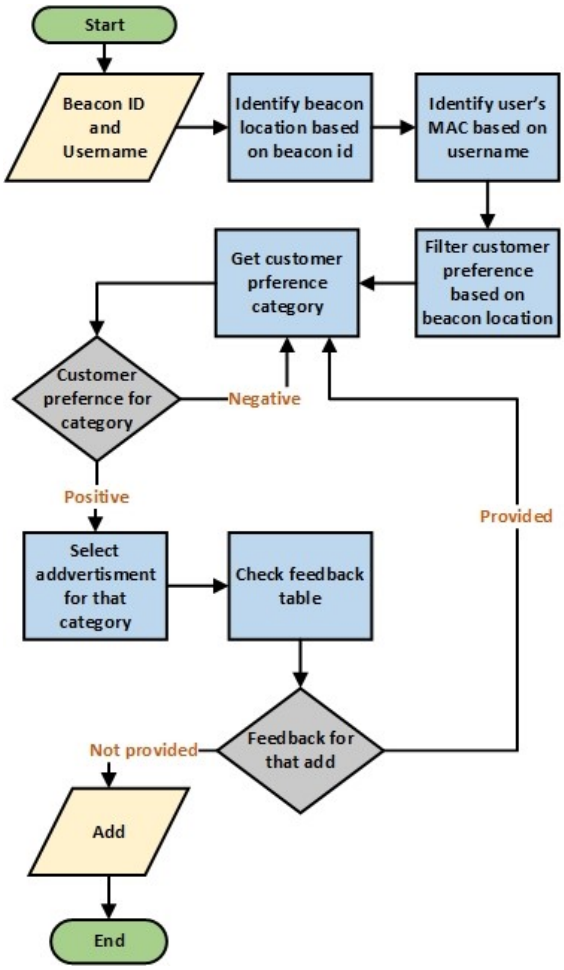

Fig. 6. Flow chart of advertisement selection process

The customer able to give and feedback indicating whether he/she is interested in an event or not, and these information is used for further analyzing.

The mobile application runs in 2 ways;

i. Manual process: User able to scan for beacons manually and get advertisements. The user able to check whether there are beacons deployed in the area.

ii. Notification based process: User do not need to manually run the application. When the user switch on Bluetooth, notifications are generated automatically in the notification bar. If the user wants to view, then he/she can click on the notification and download the advertisement. This way the user is not disturbed from his/her own routine.

Mobile application able to facilitate the customer by providing information based on customer's preferred language. This is achieved by including a QR code in the digital screens that are placed indoor which is used to broadcast various promotional value-added services. The customer can easily scan this QR code from their mobile device through the installed mobile application and then will receive multilingual information about services that is broadcasted in the digital screen.

- *Customer preference based shopping guide module*

Shopping guide module basic functionality is guiding the customer within the shopping area to interactively associate with the customer to provide easiness to their shopping experience. When a customer wants to buy a product in a supermarket, but customer is having trouble to find that product location in the supermarket. In such a situation this module guides the customer to that product by generating a map in the customer's mobile application. This allows the customer to reach the product easily within a short time period. Initially customer current location is identified by indoor positioning to provide the correct path to the selected product. That indoor positioning is performed using Magnetic Positioning Technology.

Navigator feature uses the Indoor Atlas API [7] to interact with the location service. The API sends processed sensor data to the location service, which computes the current location estimate and delivers the estimate back to the application's event listener method through the API.

The location service connects to the map database, which has the magnetic field data collected from the building using Indoor Atlas map creator application. The Indoor Atlas location service has been built on the top of Microsoft's Windows Azure cloud platform.

B. Personalized, two-way outdoor advertising process

The Geo fence module facilitates with the personalized, two-way outdoor advertising process. This process provides real-time, reliable delivery of location-based information to mobile users who are entering to the geo-fence zone. This makes users to easily find and subscribe to interesting services. This location based service is a massive transformation in marketing environment that helps to increase the overall utilization and integration of location based details into our day today lives. The location-aware digital signage system, LDSS, based on the GPS and wireless infrastructure, used a centralized system architecture. Figure 7 indicates the block diagram of the Geo-fence module.

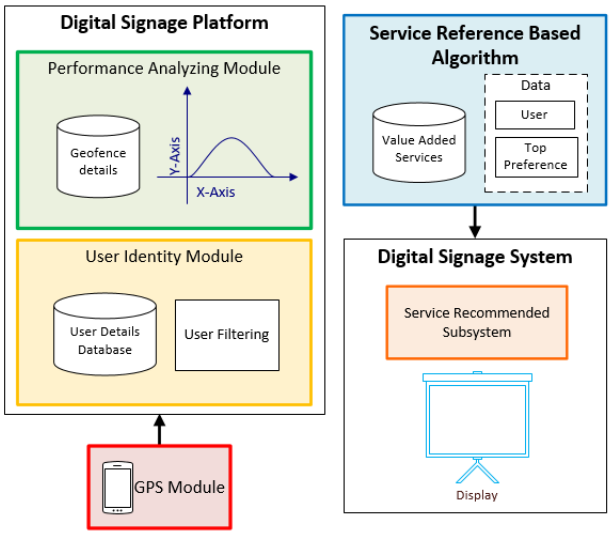

Fig. 7. Geo-fence module block diagram

GPS module communicates to a GPS application within the mobile phone, which in turn communicates with a physical GPS device inside the mobile device to find the location of the user. The GPS provides the mobile application with locations of the user and ask him/her, or the system automatically turn on Bluetooth to enable the advertising service. This location triggering helps to turn on Bluetooth in the mobile device before users enters to the geo fence to identify customers who are enrolled with our proximity application.

When turning on Bluetooth User Identity Module identifies registered users with "PRESTO" mobile application with in geo-fence area by comparing customer's Bluetooth Mac address in geo-fence area and registered customers recorded in database. After filtering that customers, call the web service that run DBSCAN algorithm and registered customers' Bluetooth MAC address is passed as a parameter to DBSCAN algorithm.

DBSCAN algorithm run based on received parameters and identifies the most appropriate value-added service that need to broadcast on digital signage according to customer preferences in geo-fence area. That generated result is passed to geo-fence module, then that value-added service is displayed in digital signage.

Services Recommend Subsystem provides a way to upload advertisements by customizing the service scheduling via the schedule management module to set advertising periods and positions.

IV. RESULTS

The main objective of the proposed advertising solution which is personalized advertising is achieved using DBSCAN algorithm. Algorithm pseudo code is as following:

```
DBSCAN(D, eps, MinPts) {
   C = 0
   for each point P in dataset D {
      if P is visited
         continue next point
      mark P as visited
      NeighborPts = regionQuery(P, eps)
      if sizeof(NeighborPts) < MinPts
         mark P as NOISE
      else {
         C = next cluster
         expandCluster(P, NeighborPts, C, eps, MinPts)
      }
   }
}
```

Algorithm mainly requires epsilon (eps) and MinPts two parameters. Algorithm behavior varies according to these two parameters for same data set.

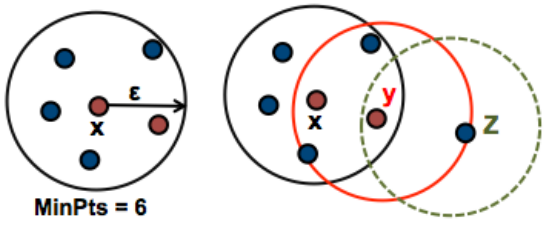

Fig. 8. DBSCAN process

For a small data set if large value for minPts parameter is defined then algorithm cannot identify clusters properly. Algorithm will not give a correct result and generate many clusters from noise. According to the test scenario digital signage module identify minimum ten customers to perform personalized outdoor advertising process. Our target is to broadcast a personalized advertisement which satisfy most of the customers. With the minimum value of ten customers our objective is to satisfy at least 5 customers. According to that requirement DBSCAN algorithm minPts parameter value is identified as five.

Other considerable parameter is eps. Using a constant value as five for minPts, different values for eps will vary the cluster identification based on the variation in the data set. Best eps value for test data is identified by changing eps value from 0.1 and analyzing how clustering is identifying. Algorithm output of most dense cluster's correlation is calculated using below equation to analyze the accuracy of algorithm output.

TABLE 2. DBSCAN algorithms test data

eps	#Noise points	#Clusters	Most dense cluster correlation
0.1	10	0	N/A
0.2	10	0	N/A
0.3	10	0	N/A
0.5	10	0	N/A
0.6	10	0	N/A
0.7	10	0	N/A
1	10	0	N/A
1.1	10	0	N/A
1.2	10	0	N/A
1.5	10	0	N/A
2	10	0	N/A
2.5	10	0	N/A
3	10	0	N/A
3.5	10	0	N/A
3.8	10	0	N/A
4	2	1	0.629722
4.1	2	1	0.629722
4.2	**2**	**1**	**0.629722**
4.3	1	1	0.547026
4.4	0	1	0.503561
4.5	0	1	0.503561

$$R = \frac{\sqrt{r_{yx_1}^2 + r_{yx_2}^2 - 2r_{yx_1}(r_{yx_2})(r_{x_1x_2})}}{\sqrt{1 - r_{x_1x_2}^2}}$$

Equation 1. Cluster Correlation

According to analysis better eps value can be define as 4.2 which identify adequately considerable clusters with minimum noise point and most dense cluster has comparatively good correlation which is moderate association relationship among data points inside the cluster.

For any data set minPts parameter value can be used as five. Eps parameter value can be used previously analyzed value but there are some situations that value will not generate best result from cluster analysis based on the variation in the data set. With that consideration eps parameter can be estimated using a k distance graph. When computing the k distance graph, set the k nearest neighbors value equal to the minimum number of points intended for DBSCAN. A reasonable choice of epsilon will be where the graph shows a strong bend. Another method to choosing eps parameter value is to rely on domain knowledge for the data, considering things like what neighbor distances between points make sense for a given metric.

V. CONCLUSION AND FUTURE WORK

This research work demonstrated novel indoor and outdoor advertising network which have personalization and two-way characteristics. This approach overcomes the existing inefficient, bothering advertising behavior that recently people are suffering from and procures higher beneficial advertising campaign methodology.

In the future work is planned to increase the effectiveness of decision-making process to enhance the personalized advertising approach by acquiring more customer preference details, shopping behaviors in deeper way.

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